

Claims

- [c1] A method of detecting and quantifying non-aqueous phase liquids in a soil sample, the method comprising the steps of:
 - measuring the bulk dielectric constant of the sample;
 - measuring the bulk density of the sample;
 - estimating the bulk porosity of the sample from the measured bulk density;
 - calculating the non-aqueous phase liquid saturation from the measured bulk dielectric constant and the estimated bulk porosity.
- [c2] The method of claim 1, wherein the step of estimating the bulk porosity of the sample from the measured bulk density assumes 100% water saturation.
- [c3] The method of claim 1, wherein the step of estimating the bulk porosity of the sample from the measured bulk density assumes a matrix density of 2.65 g/cc.
- [c4] The method of claim 1, wherein the non-aqueous phase liquid is a dense non-aqueous phase liquid.
- [c5] The method of claim 1, wherein the soil sample is in a subsurface and the steps of measuring the bulk dielec-

tric constant and measuring the bulk density are performed in situ.

- [c6] The method of claim 5, further comprising measuring the bulk dielectric constant of the sample at a plurality of depths within the subsurface and measuring the bulk porosity of the sample at the plurality of depths.
- [c7] The method of claim 6, wherein the bulk dielectric constant measurements at the plurality of depths and the bulk porosity measurements at the plurality of depths are used to calculate the non-aqueous phase liquid saturation at the plurality of depths.
- [c8] A method of detecting and quantifying in situ non-aqueous phase liquids in the subsurface, the method comprising the steps of:
 - providing at least one logging well;
 - providing an active gamma logging tool;
 - measuring the bulk density of the subsurface at a first plurality of vertical intervals along the length of the logging well utilizing the active gamma logging tool;
 - providing a cone penetrometer tool having dielectric constant measurement capability;
 - measuring the dielectric constant of the subsurface at a second plurality of vertical intervals utilizing the cone penetrometer tool;

interpolating the measured bulk density at the first plurality of vertical intervals and the measured dielectric constant at the second plurality of vertical intervals to establish a plurality of consistent vertical intervals; estimating the bulk porosity of the subsurface from the interpolated bulk density measurements, assuming 100% water saturation and a matrix density of 2.65g/cc calculating the percent dense non-aqueous phase liquid saturation at the plurality of consistent vertical intervals from the interpolated dielectric constant and the interpolated bulk porosity.

- [c9] A method of detecting and quantifying in situ non-aqueous phase liquids in the subsurface, method comprising the steps of:
 - providing a cone-penetrometer tool, further comprising a bulk density measurement device and a dielectric constant measurement device;
 - measuring the bulk density of the subsurface at a plurality of vertical intervals within the subsurface utilizing the cone penetrometer tool;
 - measuring the dielectric constant of the subsurface at the plurality of vertical intervals utilizing the cone-penetrometer tool;
 - estimating the bulk porosity of the subsurface from the measured bulk density; and

calculating the percent non-aqueous phase liquid saturation at the plurality of vertical intervals from the dielectric constant and the bulk porosity.